

ORIGINAL ARTICLE

# Hospitalizations for Stroke in France During the COVID-19 Pandemic Before, During, and After the National Lockdown

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**BACKGROUND AND PURPOSE:** In France, the entire population was put under a total lockdown from March 17 to May 11, 2020 during the peak of the coronavirus disease 2019 (COVID-19) pandemic. Whether the lockdown had consequences on the management of medical emergencies such as stroke and transient ischemic attack (TIA) has yet to be fully evaluated. This article describes hospitalization rates for acute stroke in 2 French regions that experienced contrasting rates of COVID-19 infection, before, during, and after the nationwide lockdown (January to June 2020).

**METHODS:** All patients admitted for acute stroke/TIA into all public and private hospitals of the 2 study regions were included. Data were retrieved from the National Hospitalization Database (PMSI). In the most affected region (Grand-Est), the hospitalization rates observed in April 2020 were compared with the rates in the same period in the least affected region (Occitanie) and in the 3 prior years (2017–2019).

**RESULTS:** There was a significant decline in hospitalization rates for stroke/TIA within the region most affected by COVID-19 during the month of April 2020 compared with previous years, while no significant change was seen in the least affected region. After lockdown, we observed a fast rebound in the rate of hospitalization for stroke/TIA in the most affected region, contrasting with a slower rebound in the least affected region. In both regions, patients with COVID-19 stroke more frequently had ischemic stroke, a nonsignificant greater prevalence of diabetes, they were less frequently admitted to stroke units, and mortality was higher than in patients without COVID-19.

**CONCLUSIONS:** Our results demonstrate a significant drop in stroke/TIA hospitalizations and a fast recovery after the end of the French lockdown in the most affected region, while the least affected region saw a nonsignificant drop in stroke/TIA hospitalizations and a slow recovery. These results and recommendations could be used by the health authorities to prepare for future challenges.

**Key Words:** coronavirus disease 2019 ■ hemorrhagic stroke ■ hospitalization ■ incidence ■ ischemic attack, transient ■ ischemic stroke

To date, little is known about the real impact of the coronavirus disease 2019 (COVID-19) pandemic on other medical and surgical emergencies<sup>1–4</sup> although the adverse consequences may be of importance. In patients with stroke, for instance, delays in stroke care

can have devastating effects on functional outcomes, especially with regard to patients with ischemic stroke who are unable to access to rapid revascularization therapy (intravenous thrombolysis and/or mechanical thrombectomy).<sup>5–7</sup>

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## Nonstandard Abbreviations and Acronyms

<b>ATIH</b>	Agence Technique de l'Information sur l'Hospitalisation
<b>COVID-19</b>	coronavirus disease 2019
<b>HS</b>	hemorrhagic stroke

There are conflicting findings about hospitalization rates for acute stroke and transient ischemic attack (TIA) in numerous countries during lockdown. Some studies suggest that there was an increase during the pandemic, possibly due to the deep hypercoagulable state associated with COVID-19,<sup>8,9</sup> while a great majority of studies have reported a decrease in rates.<sup>5,10–13</sup> Moreover, little is known about the changes after the first peak of the epidemic.<sup>14,15</sup>

In France, there were considerable geographic disparities in the spread of COVID-19 during the initial outbreak and the national lockdown of spring 2020 (March 17 to May 11, 2020).

These disparities provide the opportunity to describe the hospitalization rates for stroke/TIA and their trends among regions that experienced different rates of COVID-19 infection before, during, and after the lockdown.

## OBJECTIVE

The aim of this study was to evaluate the impact of the COVID-19 pandemic on the trends of the hospitalization rates for acute stroke and TIA before, during, and after the national lockdown, and to describe the proportion of these events associated with COVID-19, and the clinical characteristics of patients with stroke/TIA with COVID-19, focusing on 2 French regions in which COVID-19 spread at different rates.

## METHODS

The data found in the French National Hospital Discharge database (Program de médicalisation des systèmes d'information) was transmitted by the national agency for the management of hospitalization data. Our department's use of these data was approved by the National Committee for Data Protection. Transmission of these data to a third party is forbidden.

Programme de médicalisation des systèmes d'information data are confidential, but they are made available for researchers who meet the criteria for access (requires the approval of the National Committee for data protection) from the Agency for Information on Hospital Care (Agence technique de l'information sur l'hospitalisation).

## Study Design

We retrospectively analyzed all patients admitted to public and private hospitals in Grand-Est and Occitanie for acute stroke

subtypes (ischemic and hemorrhagic stroke) and TIA between January and June 2020, including the first peak of the pandemic and the national lockdown in April 2020. Initially, the French region of Grand-Est was the region most affected by COVID-19 and Occitanie was the region least affected by COVID-19. The Grand-Est region is located in the north-east of France and has 5.5 million inhabitants. In the 111 hospitals that managed stroke/TIA in this region, 15 706 patients were hospitalized for COVID-19 between January and June 2020. The Occitanie region is located in the south-west of France and has 5.9 million inhabitants. In the 121 hospitals that managed stroke/TIA in this region, 4075 patients were hospitalized for COVID-19 over the same period. Hospitalization rates for stroke/TIA observed in April 2020 within these 2 regions were compared with the rates from the same period during the 3 previous years (2017–2019).

This retrospective study had no impact on patient care, and all data were anonymous. This study was authorized by the French Data Protection Authority on July 3, 2020 (Registration number: DR-2020-250 on July 3, 2020).

## Hospitalization Data

Hospitalization data from January 1, 2017 to June 30, 2020 were extracted from the French National Hospital Discharge database, which collects the medical records of all patients discharged from public and private hospitals. Hospitalizations included possible hospital transfers. Stroke cases were identified according to the *International Classification of Diseases-Tenth Revision* Codes based on the discharge diagnosis: the codes for hemorrhagic stroke were I60, I61, and I629, the codes for ischemic stroke were I63 and I64, and the code for TIA was G45. We used the primary diagnoses for stroke. We only used the associated diagnoses in the case where COVID was coded as the primary diagnosis to take into account the specific guidelines for coding discharge abstracts for patients with COVID. COVID-19 was identified using specific codes created by the Agence technique de l'information sur l'hospitalisation for this pandemic.

The following variables were extracted: age in 4 classes (<65, 65–79, 80–84, and ≥85 years), sex, length of stay, hospitalization in an intensive stroke unit (SU), neurovascular risk factors (hypertension, diabetes, hypercholesterolemia, obesity, tobacco abuse, atrial fibrillation, and cancer). In France, national administrative data for stroke have been previously validated.<sup>16,17</sup>

## Statistical Analysis

Qualitative variables were presented as frequencies (percentage). Quantitative variables were presented as means±SD and medians (interquartile range, Q1–Q3). The different variables analyzed in the cohort of hospitalized patients for stroke were compared using the  $\chi^2$  test or the Fisher exact test (for qualitative variables) and Student *t* test or Mann-Whitney *U* test (for quantitative variables), according to the region, COVID-19 status, or period for hospitalization to a SU. Stroke admission rates were standardized on age and sex using census data from January 1, 2020 and provided by the French National Institute of Statistics and Economic Studies. All time trends analyses (variation in hospitalization to SU, changes in inpatient mortality,

in standardized stroke hospitalization rates) were conducted using the Cochran-Armitage test. The statistical significance threshold was set at <0.05. All analyses were performed using SAS (SAS Institute, Inc, Version 9.4, Cary, NC).

## RESULTS

In the Grand-Est region, the monthly number of stroke hospitalizations was stable from January to April in 2017 to 2019 but significantly decreased by 18% in April 2020 compared with April 2019 (Table 1, Figure 1 in the [Data Supplement](#)). Occitanie experienced a smaller, non-significant decrease in April 2020 compared with April 2019 (9%). After April, the monthly number of stroke/TIA hospitalizations increased to values similar to previous years. The rebound occurred very quickly in Grand-Est and more slowly in Occitanie.

From 2017 to 2019, standardized stroke hospitalization rates per 100 000 inhabitants significantly decreased from 232.8 to 220.7 in Grand-Est ( $P<10^{-4}$ ) while Occitanie observed no variation (from 235.1 to 239.9,  $P=0.086$ ; Table 2). In Grand-Est, we observed a significant decrease in monthly standardized hospitalization rates for the months of March from 2017 to 2020 ( $P<10^{-4}$ ). Nevertheless, this decrease was much more pronounced for the months of April from 2017 to 2020, with standardized stroke hospitalization rates at 19.0 and 15.6 per 100 000 inhabitants in 2019 and 2020, respectively ( $P=0.0014$ ). In Occitanie, no significant change in standardized stroke hospitalization rates was found for the months of March or April 2017 to 2020 ( $P=0.078$  and 0.51, respectively).

Inpatient mortality among all stroke patients did not vary significantly in the 2 regions from January to April 2020 (Table 1 in the [Data Supplement](#)).

The clinical characteristics of stroke and TIA in patients with and without COVID-19 who were hospitalized in April 2020 in Grand-Est and Occitanie are presented in Table 3. In April 2020, 102/865 patients hospitalized for acute stroke/TIA in Grand-Est had COVID-19 (11.8%). Patients with COVID-19 had more ischemic strokes, a nonsignificant greater prevalence of diabetes, they were less frequently admitted to the SU, and they had a higher mortality rate than those without COVID-19. In Occitanie, there were 24/1184 hospitalizations for stroke/TIA with associated COVID-19 infection (2.0%). In patients

hospitalized with COVID-19, the type of stroke/TIA was similar to that of patients without COVID-19, but patients with COVID-19 were less frequently admitted to SU and had poorer outcomes. Inpatient mortality among patients with COVID-19 stroke/TIA was 3× higher than that observed in patients without COVID-19 (Table 3), both for hemorrhagic stroke (43% versus 31%) and for ischemic stroke (26% versus 9%), in both regions. The proportion of TIA in patients affected by COVID-19 was lower than in nonaffected patients (7.8% versus 22.9%,  $P=0.0005$  in Grand-Est and 8.3% versus 23.3%,  $P=0.085$  in Occitanie).

The extreme age groups were more common in stroke/TIA hospitalizations with COVID-19 than without (more elderly people in both regions and more young people in Occitanie; Table 4).

In our analysis of patients admitted to a stroke unit from 2017 to 2020, we observed no change in the proportion of SU admission in Grand-Est during the month of April when stroke and TIA were grouped together, but the proportion significantly increased for TIA alone ( $P=0.041$ ; Table 5). However, in Occitanie, we observed a significant increase in SU admissions for the whole population of stroke and TIA ( $P=0.0041$ ), which was due to a significant increase in admissions for ischemic stroke alone ( $P=0.017$ ).

When we compared the clinical characteristics of patients admitted to an SU in April 2019 and those admitted in April 2020, we found no differences in age or sex in either region (Table II in the [Data Supplement](#)). However, in Grand-Est, we observed more TIA and less hemorrhagic strokes ( $P=0.016$ ), while in Occitanie the stroke types were similar in both years ( $P=0.26$ ).

## DISCUSSION

To our knowledge, this is the first study to compare hospitalization rates for stroke and TIA during and after the end of the nationwide lockdown in all the public and private hospitals of 2 large French regions differently affected by the COVID-19 crisis, as shown by the overall number of patients with COVID-19 and the prevalence of COVID-19 in stroke patients. Our results demonstrated a significant decrease in standardized stroke hospitalization rates in the most severely affected region during the first peak of the pandemic and the lockdown in April

**Table 1. Monthly Stroke/TIA Hospitalizations in Grand-Est and Occitanie Regions From January to June for Years 2017 to 2020**

Period	Grand-Est region						Occitanie region					
	January	February	March	April	May	June	January	February	March	April	May	June
2017	1 151	1 049	1 178	1 012	1154	1053	1 264	1 209	1 348	1 236	1 231	1 313
2018	1 081	993	1 073	1 078	1020	1041	1 327	1 192	1 363	1 248	1 323	1 287
2019	1 094	994	1 073	1 057	1068	960	1 301	1 218	1 304	1 305	1 343	1 220
2020	1 068	969	858	865	1 000	966	1 299	1 238	1 137	1 184	1 180	1 303

TIA indicates transient ischemic attack.

**Table 2. Standardized Stroke/TIA Hospitalization Rates Per 100 000 Inhabitants From 2017 to April 2020, in Grand-Est and Occitanie Regions**

Period	Grand-Est region		Occitanie region	
	Standardized stroke hospitalization rates	P value	Standardized stroke hospitalization rates	P value
Total year		<10 <sup>-4</sup>		0.086
2017	232.8		235.1	
2018	221.4		237.9	
2019	220.7		239.9	
March		<10 <sup>-4</sup>		0.078
March 2017	21.2		20.8	
March 2018	19.3		21.1	
March 2019	19.3		20.2	
March 2020	17.4		19.5	
April		0.0014		0.51
April 2017	18.2		19.2	
April 2018	19.4		19.3	
April 2019	19.0		20.2	
April 2020	15.6		18.3	
23rd March 2020 to 22nd April 2020	15.1		18.3	

P value of Cochran-Armitage trend test. TIA indicates transient ischemic attack.

2020 as compared with the same month in the previous years. On the contrary, the least affected region did not experience a significant change in the rate of hospitalization for stroke. Stroke patients with COVID-19 were less likely to be admitted to stroke units and had higher mortality rates than patients with stroke without COVID-19.

From a public health perspective, the impact of the COVID-19 pandemic on hospital facilities is a major issue. In our study, we found a significant 18% reduction in the number of patients hospitalized for stroke and TIA in the most severely affected region, which is lower than the rates reported in the United Kingdom (48%),<sup>18</sup> China (40%),<sup>11</sup> Belgium (40%),<sup>18</sup> the United States (39%),<sup>1</sup> Germany (35%),<sup>18</sup> Italy (26%),<sup>12</sup> and Spain (25%).<sup>14</sup> In France, a review by Liu et al<sup>18</sup> described an average drop of 23%, while a study of 3 French stroke units reported a drop of 39.6%.<sup>10</sup> These different rates may be explained in part by the fact that our study included nonspecialized public and private hospitals in addition to stroke centers and also the long recovery time for stroke patients. The results observed in countries with different health systems, unique cultural and social environments and diverse strategies for managing the COVID-19 pandemic may still suggest similar reasons for the drop in admissions. It is important to note that administrative data collection may be hindered by a delay in data collection, inducing a lack of exhaustivity. The issue of missing data has been progressively corrected in our database and should thus have a limited impact on our data, especially for the

lockdown period. This bias could also explain a part of the reported differences between countries.

Several studies that further investigated the decrease in hospitalization rates observed a significant decrease in the number of emergency calls for stroke,<sup>7,14</sup> emergency hospitalizations,<sup>13</sup> brain imaging,<sup>17</sup> and in the administration of acute revascularization therapies including intravenous thrombolysis,<sup>7,8,10-12</sup> and mechanical thrombectomy.<sup>5,7,8,10-12</sup> Zhao et al<sup>11</sup> found that the absolute number of thrombolysis and mechanical thrombectomy cases dropped by 27% and 25%, respectively, but not the rates, suggesting that patients with stroke admitted to hospitals were well managed according to the international recommendations.

Additional factors may have contributed to the decrease in hospitalization rates and could explain the results discussed above. First, fewer patients may have presented to hospitals because of confusion regarding the best course of action when stroke/TIA symptoms occurred.<sup>10</sup> Otherwise, individuals with suspected acute stroke or TIA may have been afraid of exposure to COVID-19 at the hospital<sup>10,12</sup> or had difficulty finding transportation during the lockdown. In hospitals, patients with COVID-19 may have been given the priority in emergency units, and the public messages to stay at home to avoid COVID-19 contamination<sup>11,18</sup> and to avoid putting additional pressure on hospitals and health care workers may also have played a role in discouraging individuals from seeking appropriate care, in addition to social isolation (mainly for women).<sup>19</sup> Some patients with severe stroke might have died at home, and there was a potential for misdiagnosis by physicians who may have overlooked the symptoms of stroke because of the severe respiratory symptoms of COVID-19. A stunning phenomenon, as observed in extraordinary situations like earthquakes or wars, has also been suggested to explain a similar reduction in the number of myocardial infarctions.<sup>20</sup> The last explanation could be a decrease in the number of stroke/TIA cases associated with the decline in air pollution observed during lockdown, since air pollution is a known trigger of vascular events.<sup>21</sup>

The consequences of the lack of management of acute stroke or TIA are serious, with risks that include increased mortality rates, more severe complications, and lost opportunities to receive effective treatments and appropriate secondary prevention.

In April 2020, in the most severely affected region, 11.8% of hospitalized stroke/TIA patients were diagnosed with COVID-19 compared with only 2% in the least affected region, underlining the great disparities between the 2 regions. These results are difficult to compare with previous studies, which only reported the estimated prevalence of stroke in patients with COVID-19, ranging between 1% and 6%.<sup>22-26</sup>

The effect of COVID-19 on the clinical features of stroke is a subject of ongoing debate in the literature. In

**Table 3. Clinical Characteristics of Stroke Subtypes and TIA Among COVID-19 Patients vs Non-COVID-19 Patients Hospitalized in April 2020 in Grand-Est and Occitanie Regions**

	Grand-Est region				Occitanie region			
	Total, N (%)	COVID-19		P value	Total, N (%)	COVID-19		P value
		+N (%)	-N (%)			+N (%)	-N (%)	
Number	865	102	763		1184	24	1160	
Age, y								
Mean (SD)	73.0 (14.8)	74.6 (14.5)	72.8 (14.8)	0.26	73.6 (14.2)	74.5 (15.7)	73.5 (14.1)	0.75
Median (IQR)	76 (20.0)	76 (21.0)	76 (20.0)		75 (20.0)	76 (28.5)	75 (20.0)	
Male sex	446 (51.6)	53 (52.0)	393 (51.5)	0.93	616 (52.0)	13 (54.2)	603 (52.0)	0.83
Stroke subtypes and TIA				0.0021				0.20
Transient ischemic attack	183 (21.2)	8 (7.8)	175 (22.9)		272 (23.0)	2 (8.3)	270 (23.3)	
Ischemic	554 (64.0)	76 (74.5)	478 (62.7)		754 (63.7)	19 (79.2)	735 (63.4)	
Hemorrhagic	128 (14.8)	18 (17.7)	110 (14.4)		158 (13.3)	3 (12.5)	155 (13.3)	
Hypertension	650 (75.1)	73 (71.6)	577 (75.6)	0.37	687 (58.0)	13 (54.2)	674 (58.1)	0.70
Diabetes	231 (26.7)	33 (32.4)	198 (26.0)	0.17	278 (23.5)	5 (20.8)	273 (23.5)	0.76
Obesity	215 (24.9)	27 (26.5)	188 (24.6)	0.69	167 (14.1)	1 (4.2)	166 (14.3)	0.24
Hypercholesterolemia	329 (38.0)	35 (34.3)	294 (38.5)	0.41	287 (24.2)	3 (12.5)	284 (24.5)	0.18
Tobacco consumption	146 (16.9)	18 (17.7)	128 (16.8)	0.83	157 (13.3)	5 (20.8)	152 (13.1)	0.24
Atrial fibrillation	264 (30.5)	37 (36.3)	227 (29.8)	0.18	312 (26.4)	6 (25.0)	306 (26.4)	0.88
Cancer	157 (18.2)	19 (18.6)	138 (18.1)	0.89	194 (16.4)	7 (29.2)	187 (16.1)	0.096
Intensive stroke unit	445 (51.5)	17 (16.7)	428 (56.1)	<10 <sup>-4</sup>	786 (66.4)	7 (29.2)	779 (67.2)	<10 <sup>-4</sup>
In-patient mortality	111 (12.8)	28 (27.5)	83 (10.9)	<10 <sup>-4</sup>	120 (10.1)	7 (29.2)	113 (9.7)	0.0074

P value of the  $\chi^2$  test or the Fisher exact test (for qualitative variables) and Student *t* test or Mann-Whitney *U* test (for quantitative variables). COVID-19 indicates coronavirus disease 2019; IQR, interquartile range; N, number; and TIA, transient ischemic attack.

our study, stroke hospitalizations associated with COVID-19 were more frequently for ischemic stroke, which is consistent with previous studies.<sup>21-27</sup> In both regions, the proportion of TIA was lower in patients with COVID-19, suggesting that patients who were ill with COVID-19 and who experienced a TIA did not seek medical attention for their neurological symptoms.<sup>15</sup>

Additionally, we observed that patients were less frequently admitted to the SU during the lockdown and had poorer prognoses. More specifically, inpatient mortality was 3× higher among COVID-19 stroke patients than non-COVID-19 stroke patients, both in hemorrhagic and ischemic stroke. Similarly, an American single-center retrospective cohort study including 3556 patients with COVID-19 found that the 19 patients who had a concomitant stroke had more severe stroke and a higher risk of in-hospital mortality when compared with historical stroke controls<sup>28</sup> as in our study. Another retrospective single-center cohort analysis observed that patients with concomitant stroke and COVID-19 had higher modified Rankin Scale scores at discharge.<sup>29</sup>

While previous reports have suggested that stroke in COVID-19 could be related to atheroma and its associated vascular risk factors,<sup>26</sup> thrombotic microangiopathy, paradoxical embolism or that it may be a direct effect of COVID-19,<sup>27,28,30,31</sup> the mechanisms underlying this finding requires further exploration.

After the lockdown, we found that the stroke hospitalization rate recovered more quickly in the most affected region than in the least affected region. This difference may be a result of a number of factors, including the more marked drop in hospitalizations observed in Grand-Est during the lockdown and the strong pressure of stroke incidence, a decrease in the number of hospitalized COVID-19 patients, a change in patient behavior when experiencing the first symptoms of stroke, a reactivation of emergency stroke networks, and perhaps an improvement in the available hospital facilities. To our knowledge, no data are available on the trends of stroke/TIA hospitalization after lockdown except a short report showing a continued reduced number of stroke admissions over a short post-lockdown period (15 days) in March 2020.<sup>14</sup> However, this study did not include primary and secondary public and private hospitals. Another study including 21 stroke centers in California<sup>15</sup> observed a continued decrease in stroke alert volume during the gradual reopening of California up until May 9, 2020.

To avoid a similar drop in stroke hospitalizations in the future, we can suggest the following recommendations, as reported by Zhao et al<sup>11</sup>: improvement of stroke awareness education to recognize stroke symptoms using the FAST (Face, Arm, Speech, Time) acronym, encouraging individuals to seek help by immediately calling the emergency number, implementation of a fast-track COVID-19 screening and tracing for patients with stroke

**Table 4. Distribution of Stroke/TIA Hospitalizations by Age Class in April 2019 and 2020 and According to COVID-19 Status for April 2020 in Grand-Est and Occitanie Regions**

April	Grand-Est region			Occitanie region		
	2019	2020		2019	2020	
COVID-19	No	No	Yes	No	No	Yes
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Age, y						
(0–64)	264 (25.0)	200 (26.2)	23 (22.5)	314 (24.1)	266 (22.9)	8 (33.3)
(65–80)	358 (33.9)	269 (35.3)	36 (35.3)	453 (34.7)	452 (39.0)	5 (20.8)
(80–84)	170 (16.1)	114 (14.9)	10 (9.8)	193 (14.8)	147 (12.7)	1 (4.2)
>85	265 (25.0)	180 (23.6)	33 (32.4)	345 (26.4)	295 (25.4)	10 (41.7)
Total	1057	763	102	1305	1160	24

COVID-19 indicates coronavirus disease 2019; N, number; and TIA, transient ischemic attack.

associating both brain imaging and a full chest computed tomography scan, prioritization of vital emergencies such as stroke, allowing a rapid initiation of stroke therapy despite the heavy COVID-19 diagnosis process, using Telestroke, and ensuring lasting activation of the stroke networks. In addition, improving the relationships between the scientific community and public health policymakers could be a means to encourage the population to adhere to appropriate health measures. Finally, stroke centers should share their clinical and procedural experience with COVID teams.<sup>32</sup>

Several limitations must be acknowledged. First, this was a simple descriptive retrospective and observational study. Access times to hospital and revascularization procedures were not analyzed and neither was disability. Moreover, changes in stroke unit admission can depend on the number of available beds, which may vary over time and not depend only on the actual number of patients with stroke, thus limiting the interpretation of these data.

Also, the differences were only observed over the period of a single month (April) and not on the real duration

**Table 5. Variation in Stroke Subtypes and TIA Hospitalization in Stroke Units in April of 2017 to 2020 in Grand-Est and Occitanie**

Stroke mechanism	Period		Grand-Est region		Occitanie region	
			Stroke unit	Total	Stroke unit	Total
			N (%)	N	N (%)	N
Total	2017	April	477 (47.1)	1 012	750 (60.7)	1 236
	2018	April	542 (50.3)	1 078	773 (61.9)	1 248
	2019	April	532 (50.3)	1 057	819 (62.8)	1 305
	2020	April	445 (51.5)	865	786 (66.4)	1184
<i>P</i> value			0.072		0.0041	
TIA	2017	April	97 (36.5)	266	159 (53.5)	297
	2018	April	76 (30.3)	251	162 (50.9)	318
	2019	April	70 (31.1)	225	145 (45.6)	318
	2020	April	88 (48.1)	183	155 (57.0)	272
<i>P</i> value			0.041		0.80	
Ischemic stroke	2017	April	346 (56.4)	613	511 (68.0)	751
	2018	April	410 (61.3)	669	517 (69.7)	742
	2019	April	403 (60.7)	664	571 (72.5)	787
	2020	April	317 (57.2)	554	550 (72.9)	754
<i>P</i> value			0.80		0.017	
Hemorrhagic stroke	2017	April	34 (25.6)	133	80 (42.5)	188
	2018	April	56 (35.4)	158	94 (50.0)	188
	2019	April	59 (35.1)	168	103 (51.5)	200
	2020	April	40 (31.3)	128	81 (51.3)	158
<i>P</i> value			0.35		0.090	

*P* value of Cochran-Armitage trend test. N indicates number; and TIA, transient ischemic attack.

of the lockdown. A potential misclassification-related or under-detection-related bias may have occurred, especially for comorbidities. Another limitation is that the Programme de médicalisation des systèmes d'information inpatient database for COVID-19 was developed with accelerated transmission of data relating to COVID-19 patients from March 2020, on the request of the government according to the decree of April 21, and these data are therefore pending consolidation. Moreover, the information in the database is completed over time, especially in the 3 months following hospital discharge, leading to a probable underestimation of the real number of stroke/TIA hospitalizations after the lockdown period.

The present study has several strengths. First, we included 2 large regions totaling 11.3 million inhabitants who were put under the same complete lockdown. Data for both ischemic and hemorrhagic stroke and TIA were obtained for all cases managed in the public and private hospitals of the 2 regions before, during, and after the lockdown. The potential for a seasonal effect was limited by using the 3 last years as a historical control. The month of April was the peak of the pandemic in France, and the entire month was a national lockdown.

## CONCLUSIONS

The marked reduction in hospitalization rates for stroke/TIA in the region most affected by COVID-19 in France suggests that the lockdown induced by COVID-19 was a barrier to hospitalization for stroke/TIA. However, this region saw a rapid rebound in the number of admissions following the end of the lockdown. Given the potential deleterious consequences for patients with acute stroke/TIA who do not receive appropriate care, the general public should be made aware of the importance of contacting the emergency services if a stroke or TIA is suspected, and efficient stroke care pathways need to be maintained, even during a crisis like the COVID-19 epidemic. To better understand the decrease in stroke hospitalization rates and the consequences on disability and mortality, data from population-based stroke registries will be essential to distinguish between actual variations in incidence and the influence of the lockdown. The health authorities should be made aware of these findings and recommendations to implement appropriate public health policy in the context of the ongoing COVID-19 crisis.

## ARTICLE INFORMATION

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